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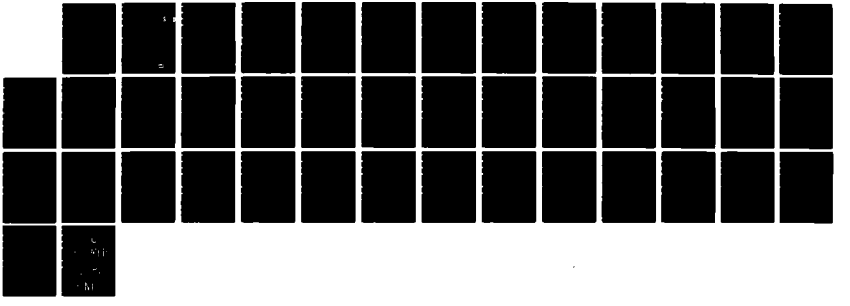

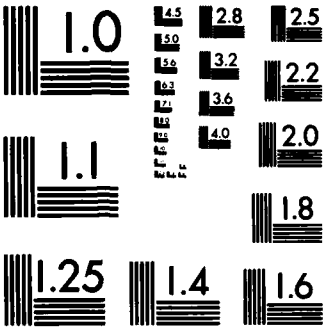

A REVIEW

OF

THE AQUATIC BIOLOGICAL RESOURCES OF

THE ATLANTIC COASTAL AREA

OFF VIRGINIA BEACH, VIRGINIA

Planning Aid Report by the
U.S. Fish and Wildlife Service
Under Provisions of the
Fish and Wildlife Coordination Act
For a Proposed Ocean Dredged Material Disposal Site
by the Norfolk District,
U.S. Army Corps of Engineers

February, 1984

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This report will provide planning aid information for the Norfolk Harbor Deepening Study. Consideration is currently being given to establishing a new dredged material disposal site further inshore from the previously proposed site, located approximately 17 miles east of the Bay mouth. We understand that although no firm alternative site has been selected for study, one alternative being considered is deposition of disposal material north of the previously utilized Dam Neck disposal site in a manner to create an off-shore bar.

This report will attempt to describe the baseline biological conditions in the study area. Because of the short time frame, absence of project specifics, and broad scope of this report, the level of detail of our treatment of this ecologically complex area will necessarily be limited. As the project requirements become better defined, we will be able to provide more detailed information on particular areas of concern.

For the purposes of this report we are considering the study area to be the area bounded by 37 degrees 10' latitude on the north, 36 degrees 40' latitude on the south, 75 degrees 40' longitude on the east and the shoreline and Bay mouth on the west (Figure 1). The ecology of this area is extremely dynamic. As is typical of mid-Atlantic coastal areas, the biological make-up changes dramatically on a seasonal basis. However, it is the proximity of the Chesapeake Bay, the largest estuary on the east coast, which primarily adds to the complexity and importance of this area.

Phytoplankton

Phytoplankton in the study area are dominated by lower Chesapeake Bay species which are transported eastward from the mouth of the Bay and then southward along the Virginia coast by the Chesapeake Bay plume. Species composition fluctuates seasonally. Diatoms are typically dominant in the fall, winter and spring, while in the summer there is a mixture of diatoms, phytoflagellates and nannoplankters. Moving away from the Bay mouth and out over the continental shelf, the phytoplankton composition changes to reflect an increase in shelf species and a decrease in concentration. Marshall (1980) investigated the phytoplankton within the Bay plume and adjacent shelf waters. Based on his sampling (Figure 2) he identified phytoplankton assemblages within the Bay plume and adjacent shelf water for March, June and October (Table 1). His findings also show that phytoplankton cell concentrations in the Bay plume water are significantly higher than in shelf waters outside the plume (Figure 3). Similarly, an examination of respiration rates in the Bay plume (Robertson and Thomas, 1981) indicated that the plume supports a higher level of biological activity than adjacent non-affected shelf waters.

Zooplankton

The zooplankton forms a vital part of the ecological picture in the study area. Not only does it provide an important trophic link between the primary production of the phytoplankton and higher animal forms, but it

also includes the planktonic larval stages of many marine and estuarine invertebrates and fish. Unfortunately, detailed comprehensive zooplankton studies in the study area are lacking. Researchers from Old Dominion University have been sampling zooplankton in the area regularly for two years, but their collections have not yet been analyzed. There are, however, a few studies available from which information on the zooplankton composition in the study area can be inferred. Focusing only on molluscs, decapods and fish, the U.S. Fish and Wildlife Service (1981) made six meroplankton collections in and around Rudee Inlet. Species and abundance from two of their stations at the mouth of Rudee Inlet are shown in Table 2. Grant and Olney (1979 and 1983) studied zooplankton in the lower Chesapeake Bay. Their sampling stations closest to the study area were in the vicinity of the Bay Bridge Tunnel. A list of species which they found at these stations is shown in Table 3. Grant (1979) surveyed zooplankton on a seasonal basis in the Middle Atlantic Bight. A list of species from his LI station, located approximately 20 miles offshore of Wachapreague is shown in Table 4. The locations of the zooplankton collections made in the above mentioned studies are shown in Figure 4. The zooplankton composition in the study area is likely to include a mixture of the species identified in these studies; that is to say, there will be a mixture of estuarine species from the Bay and continental shelf species. The relative composition of these species assemblages will vary with changes in the Bay discharge and meterological conditions. Other complicating factors include tremendous seasonal shifts in species composition, diurnal vertical migrations which can bias sampling efforts, and substantial natural year to year variation. For these reasons it seems likely that the study area would include a large number of species which do not appear in any of the surveys we have reported.

The zooplankton includes many important species from higher trophic levels which are present during their developmental stages, mainly eggs and larvae. Of the species which were identified in the three studies mentioned above, there were a total of 32 species of molluscs, 38 species of decapods and 41 species of fish present in the zooplankton. The eggs and larvae of many decapods and fish were particularly prevalent in the late spring and summer, and were frequently concentrated in the surface layers.

Although there are several commercially and recreationally important fish species which will occur in the zooplankton in the study area, the blue crab (Callinectes sapidus) may be the most important species to regularly occur in high concentrations. Chesapeake Bay blue crabs spawn in the lower Bay during the summer months. Recent studies indicate that after hatching the larvae move into the neuston (surface layer) and are transported out of the Bay (Provenzano et al., 1982). Larval development occurs in offshore waters in the neuston (Smyth, 1980; McConaugha et al., 1983). Larval development to the megalopa stage has been estimated to take 30 to 40 days (McConaugha et al., 1983). Since the Chesapeake Bay plume moves southward toward Cape Hatteras, it is not clear how the crab larvae avoid being trapped in this flow and lost from the Chesapeake Bay system. However, since the larvae occupy the surface layer, wind driven surface currents may play a major role in determining their distribution. Johnson et al. (1983) have postulated that the southerly winds common in this area in the summer could retain the

larvae in the offshore waters near the Bay mouth, thereby facilitating their recruitment back into Chesapeake Bay. The dimensions of this nearshore "nursery area" have not as yet been determined.

Benthic Fauna

There have been several studies on benthic fauna at various locations within the study area. Our office conducted a one time survey of benthic infauna at 8 stations and epifauna at 3 additional stations approximately 3 miles offshore from Virginia Beach (Figure 5) in June of 1982. The results from this study were submitted to your office in a planning aid report for the Virginia Beach Hurricane Protection Study (USFWS, 1982). In this report we also reviewed other benthic studies conducted on the mid-Atlantic continental shelf. Species lists from this study are shown in Tables 5 and 6. The Hampton Roads Sanitation District has been conducting benthic surveys in the vicinity of their Virginia Beach sewage treatment plant discharge pipe for several years. Although these data are not presently available, a species inventory from an earlier study done for them by Hydroscience, Inc. (1974) is shown in Table 7 and Figure 6. Based on these studies it appears that the study area supports a productive benthic faunal population which in general character is typical of the mid-Atlantic inner continental shelf.

Finfish

The fishery resources in the study area are rich and varied. A species list compiled from National Marine Fisheries Service groundfish trawl surveys between 1977 and 1980 is given in Table 8. The surveys identified 76 species, but this is far from a complete list of the species that use the area. As is typical for the mid-Atlantic region, most species undergo seasonal migrations. The species composition in the study area is also strongly influenced by the large number of species which migrate in and out of the Chesapeake Bay. Of the 209 marine and estuarine fish species known to occur in Chesapeake Bay, 180 species migrate in and out of the Bay (Musick, 1972). Spring and fall are the peak migration periods. It is of particular interest that many species migrate through the area during their more vulnerable larval or early juvenile stages on their way to nursery areas within Chesapeake Bay. These would include species of commercial and recreational importance such as menhaden (Brevoortia tyrannus), weakfish (Cynoscion regalis), croaker (Micropogon undulatus), spot (Leiostomus xanthurus) and summer flounder (Paralichthys dentatus) (Gosselein and Azarovitz, 1982). Weakfish spawn in the lower Bay and coastal waters in the summer. Their larvae are planktonic until the later stages of development when they become demersal (Mercer, 1983). In a survey of lower Chesapeake Bay ichthyoplankton, Olney (1983) found early stage weakfish larvae at densities up to 966/100 m^2 near the Bay mouth. Menhaden, croaker, spot and summer flounder spawn in offshore waters. Their larval and postlarval stages appear to follow inshore bottom currents into Chesapeake Bay (U.S. Dept of the Interior, 1970).

Commercial Fisheries

The commercial fisheries in the Atlantic Ocean off Virginia Beach are found in two general areas. The "offshore" fishery occurs in deep water from 20 to 100 miles or more off the coast and consists of oceanic species such as the surf clam, scallop, and lobster, and deep water finfish such as tuna, dolphin and bonito. The "inshore" fishery occurs in the nearshore area from just outside the breaker zone to about 3 to 4 miles offshore. This fishery mainly harvests the finfish that migrate along the Atlantic coast and into and out of the Chesapeake Bay. The following is a brief discussion of the major inshore fisheries, which is accompanied by a map that shows the locations of these fisheries. It is based on discussions with the Virginia Institute of Marine Science, the Virginia Marine Resources Commission, and local watermen and seafood dealers.

There is a small fishery for blue crabs in the area, which is incidental to the major blue crab fishery within the Chesapeake Bay. A summer crab pot fishery exists from Cape Henry south to below Rudee Inlet, immediately east of the breaker zone and in Smith Inlet on the Eastern Shore. The crab pot fishery has been restricted within the mouth of the Chesapeake Bay by the State of Virginia because the lower Chesapeake Bay is the blue crab spawning and nursery area. Although the Virginia Beach pot fishery is outside of the restricted zone, most of the crabs that are caught in this area are also the spawning females. A winter crab dredge fishery exists along the flanks of the Chesapeake Bay entrance channels. This area is only fished during good weather conditions. The majority of the winter fishery occurs inside the mouth of the Chesapeake Bay.

A small conch fishery (Busycon sp. and Strombus sp.) occurs along Virginia Beach from about 1.5 to 3 miles offshore. This fishery takes place year round but is usually incidental to the more important finfisheries. The abundance of conch appears to vary from year to year, which may be related to fishing pressure.

A purse seine fishery for menhaden is located at the mouth of the Chesapeake Bay from late May through October. Purse seining may also occur in the nearshore area of the Atlantic Ocean during this period if spotter planes locate large concentrations of fish.

A gill net fishery is located from just outside the breaker zone to about the 20-foot contour south of the mouth of the Chesapeake Bay down to the North Carolina state line. Restrictions by the Navy limit fishing off the Dam Neck area. A shad fishery (Alosa sp.), utilizing floating gill nets, occurs during the spring run of shad into the Chesapeake Bay from March through April. Anchored gill nets are fished in the area between April and September, with the largest catches during the spring and fall migrational periods. The primary species which are caught are bluefish (Pomatomus saltatrix), croaker, spot and sea trout (Cynoscion regalis and C. nebulosus).

The most important fishery in the study area is the trawl fishery, which extends from 1/4 to 4 miles offshore, both north and south of the mouth of the Chesapeake Bay. The primary fishery, however, is south of Cape Henry.

There is an intense flounder fishery (primarily summer flounder, (Paralichthys dentatus) in the fall between about October and December. Other major species which are caught during the spring and fall migrations into and out of the Chesapeake Bay include spot, croaker, sea trout and bluefish. Striped bass (Morone saxatilis) were previously caught during the winter; however, the decline of the striped bass stocks in recent years has eliminated this fishery.

It is difficult to determine the size and economic value of the commercial fisheries in the study area. The methods that have been used by the National Marine Fisheries Service and the Virginia Marine Resources Commission to compile the statistics on the annual landings of commercial species from the Atlantic Ocean will not allow a breakdown of the catches on a small scale. Therefore, catch data for the study area includes a large area that extends from the shoreline to 75 degrees longitude and from 36 degrees to 37 degrees latitude. Catch data from the period of 1972 to 1981 have previously been compiled for the Norfolk Harbor Deepening Study and can be provided in draft form if necessary.

One of the unanswered questions regarding the commercial fisheries is whether the location of the fisheries adequately reflects the actual limits of the resources. For example, it is known that blue crabs extend much further offshore than what the extent of the crab pot fishery would indicate. However, fishermen find that it is both uneconomical and impractical to set their pots in offshore areas. This may also be the case with the finfisheries. Several watermen have indicated that they do not trawl further offshore than 4 miles because the bottom is bad, there are many obstructions, and because of the shipping lanes. Therefore, while it is speculated that the major concentrations of finfish occur within the 3 mile zone, it is possible that these fish are also found further offshore, but in lesser numbers. Of course, the location of migrating fish along the Virginia coast can vary greatly from year to year, depending on such variables as weather conditions, water temperatures, current patterns and food sources.

Recreational Fisheries

There is a substantial amount of recreational fishing in and around the study area. It is derived from commercial charter and head boats, private boats, pier fishing and beach fishing. The accompanying map displays some particularly popular fishing spots and target species. The map is based on information from the publication Saltwater Sport Fishing and Boating in Virginia (1981), and discussions with VIMS and local charter boat captains. It should be realized, however, that substantial year to year variation is expected depending on the condition of the stocks, climatic conditions, etc. The sport fishing season usually begins in March and early April with the arrival of Atlantic (Boston) mackerel (Scomber scombrus) in water 4 to 12 miles off the Virginia coast. These fish remain in the area only a short time before migrating northward. Black sea bass (Centropristis striata) and tautog (Tautoga onitis) are sought after on wrecks and artificial reefs which exist in the area. Black sea bass are caught from

spring to fall, while tautog are more restricted to just the spring and fall months (Marshall and Lucy, 1981). Bluefish are caught throughout the area, especially around the Chesapeake Light Tower, from spring to fall. Weakfish, croaker, spot and summer flounder are also caught from late spring to fall, although these fish are more frequently sought after inside the Bay mouth. It should be noted that fishing even occurs within the restricted area around Cape Henry despite the regulations prohibiting "anchoring, trawling, fishing and dragging." Fishing for bluefin tuna (Thunnus thynnus) occurs 10 to 30 miles offshore in June and July. King mackerel (Scomberomorus cavella) are also caught in this vicinity from late August to October. Other pelagic game species such as white marlin (Totrapturus albidus), wahoo (Acanthocybium solardii), false albacore (Euthynnus alletteratus), skipjack tuna (Katsuwonus pelamis), dolphin (Coryphaena hippurus), Atlantic bonita (Sarda sarda), blue marlin (Makaira nigricans), and yellowfin tuna (Thunnus albacares) are caught in deeper waters, generally 30 to 50 miles offshore.

Endangered Species

The only endangered or threatened species which would occur in the study area on more than an occasional or transient basis are marine turtles. The loggerhead turtle (Caretta caretta), which is Federally listed as threatened, and the leatherback (Dermochelys coriacea) and Atlantic ridley (Lepidochelys kempis) turtles, which are Federally listed as endangered, are known to frequently occur in the study area from May through October (Richard Byles, VIMS, personal communication). Leatherbacks occur around the Bay mouth where they often feed on jellyfish. Loggerheads and ridleys, especially the juveniles, have more of a tendency to penetrate further up the Bay. Both these species spend a good deal of time on the bottom feeding on epifaunal invertebrates. All three species are under the jurisdiction of the National Marine Fisheries Service (except when nesting) and further information can be obtained by contacting Doug Beach, NMFS, Gloucester, Massachusetts, at (617) 281-3600.

Miscellaneous Resource Considerations

The area extending from Assateague to Fisherman's Island and offshore for 10 miles is on the NOAA site evaluation list for consideration as a marine sanctuary. This does not confer any specific statutory protection on the area, but merely indicates that the site is included within a pool of 39 nationwide sites from which individual sites can be chosen for study when funds become available. Most of Fisherman's Island, located on the north side of the Bay mouth, is a National Wildlife Refuge known for having a wide variety of bird life which are particularly abundant during seasonal migratory periods. The Back Bay National Wildlife Refuge and False Cape State Park are located to the south of the study area.

Summary

The dominant factor influencing the biological make-up of the study area is its position adjacent to the mouth of the Chesapeake Bay. The Bay, which is the largest estuary on the east coast, exerts a tremendous influence. As the Bay plume sweeps over this portion of the inner continental shelf, it contributes nutrients and other materials, resulting in enhanced primary production compared to adjacent shelf waters. A critical period in the life cycle of the Chesapeake Bay blue crab occurs in this area when, after spawning in the lower Bay, the crab larvae enter the surface waters and are transported out of the Bay. After undergoing larval development in shelf waters, the post-larval crabs must pass through the area on their way back into the Bay.

The proximity of the Bay mouth also dictates that there will be extensive fish migrations through the study area. This would also include the vulnerable larval and juvenile stages of many ocean spawning species passing through the area on their way to estuarine nursery grounds.

Detailed information on the nearshore spawning and nursery areas and migratory routes of most of the finfish species and blue crabs is not available. Since the study area comprises one of the most biologically unique and important areas along the Atlantic Coast, and is vital to the maintenance of the Chesapeake Bay resources, it is imperative that any proposal to modify this area must accurately define the impacts of such a project. Unless it can be reasonably determined that there will be no adverse impacts associated with dredged material disposal, this area should not be used for a permanent, long-term disposal site.

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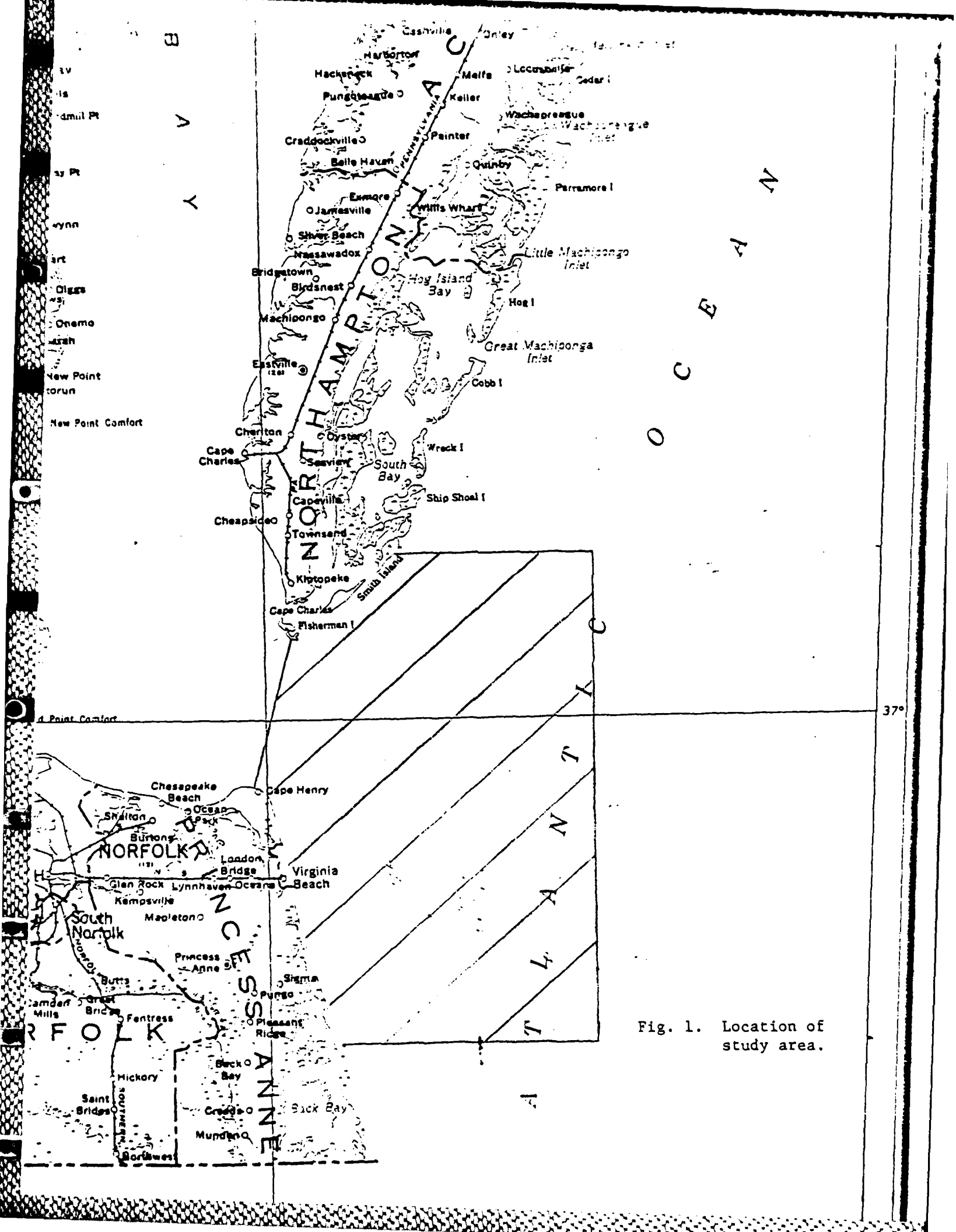


Fig. 1. Location of study area.

Fig. 2. Stations locations for the phytoplankton sampling of Marshall (1981).

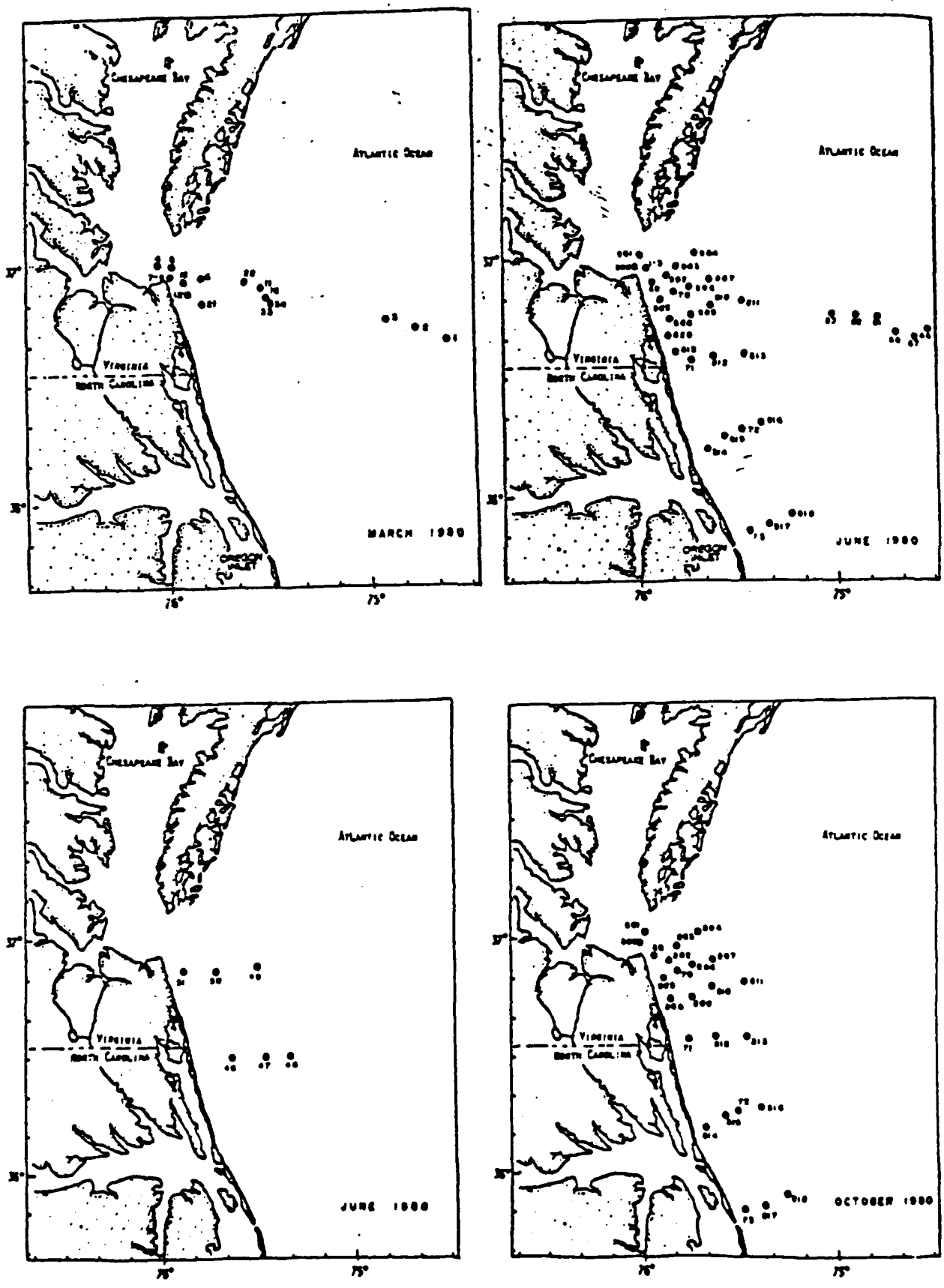


Fig. 3. Phytoplankton cell concentrations from Marshall (1981) within the Chesapeake Bay plum and adjacent shelf waters for March, June, and October 1980.

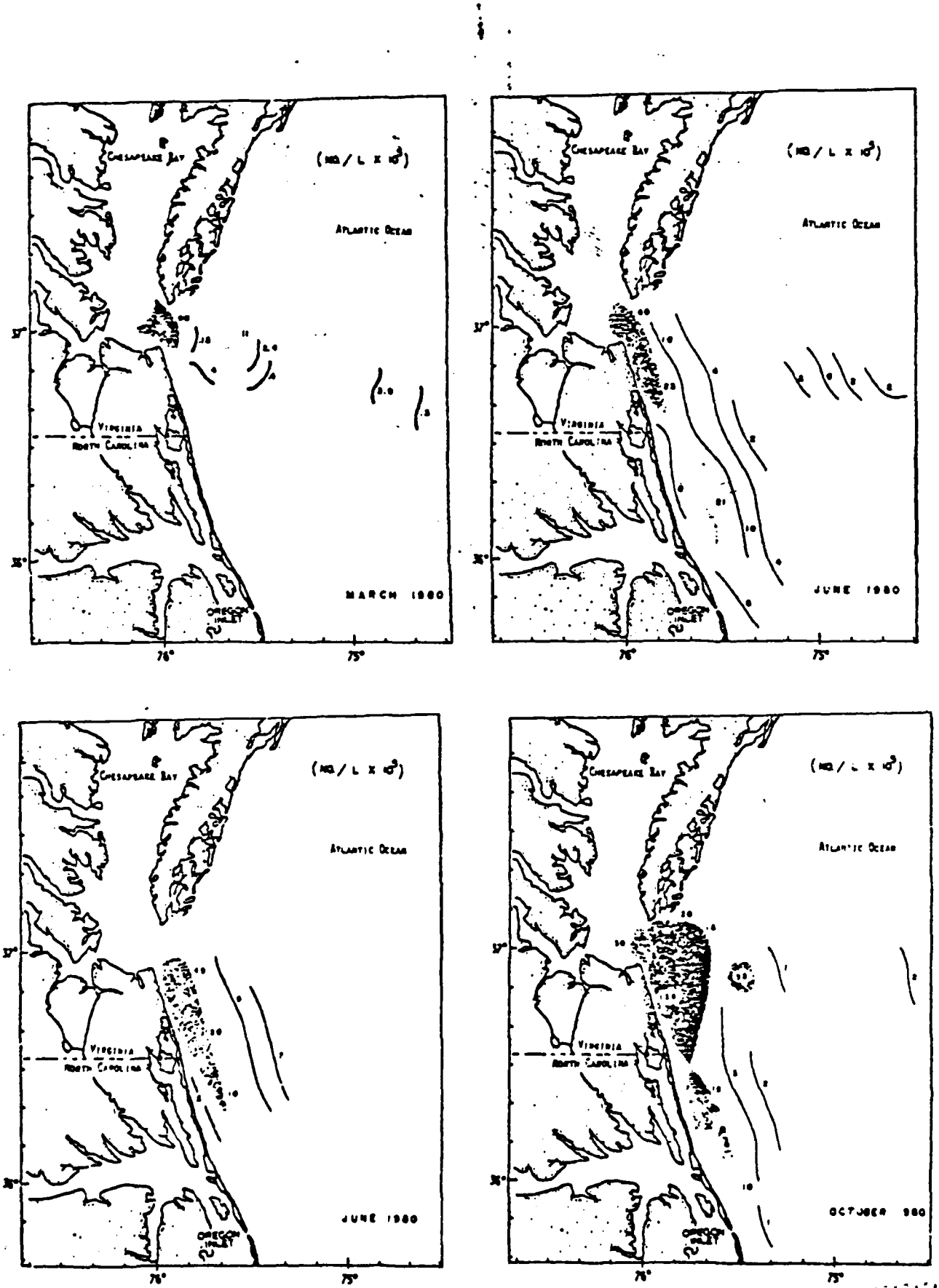
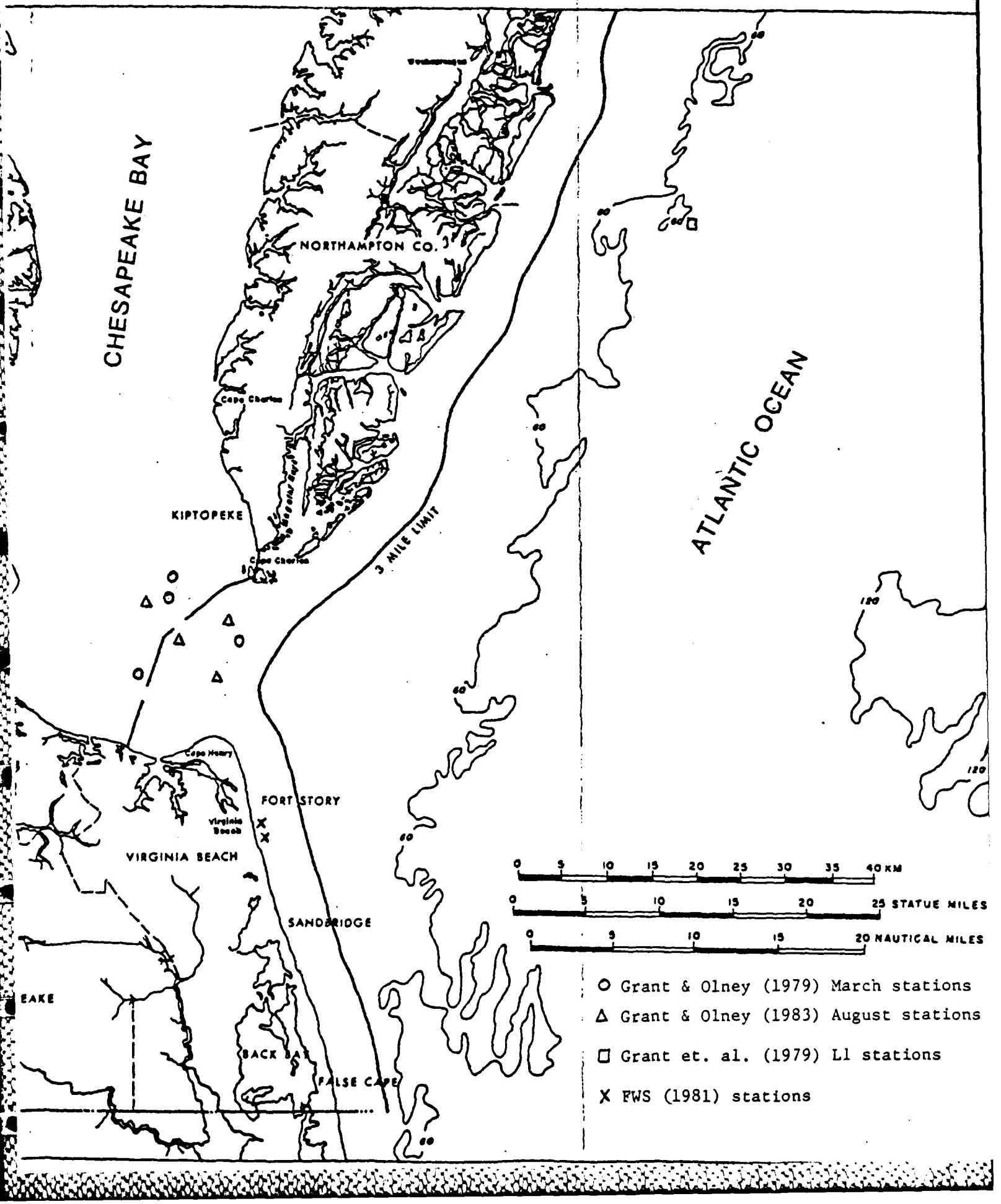


Fig. 4. Station locations for zooplankton collections.



sampled by USFWS (1982).

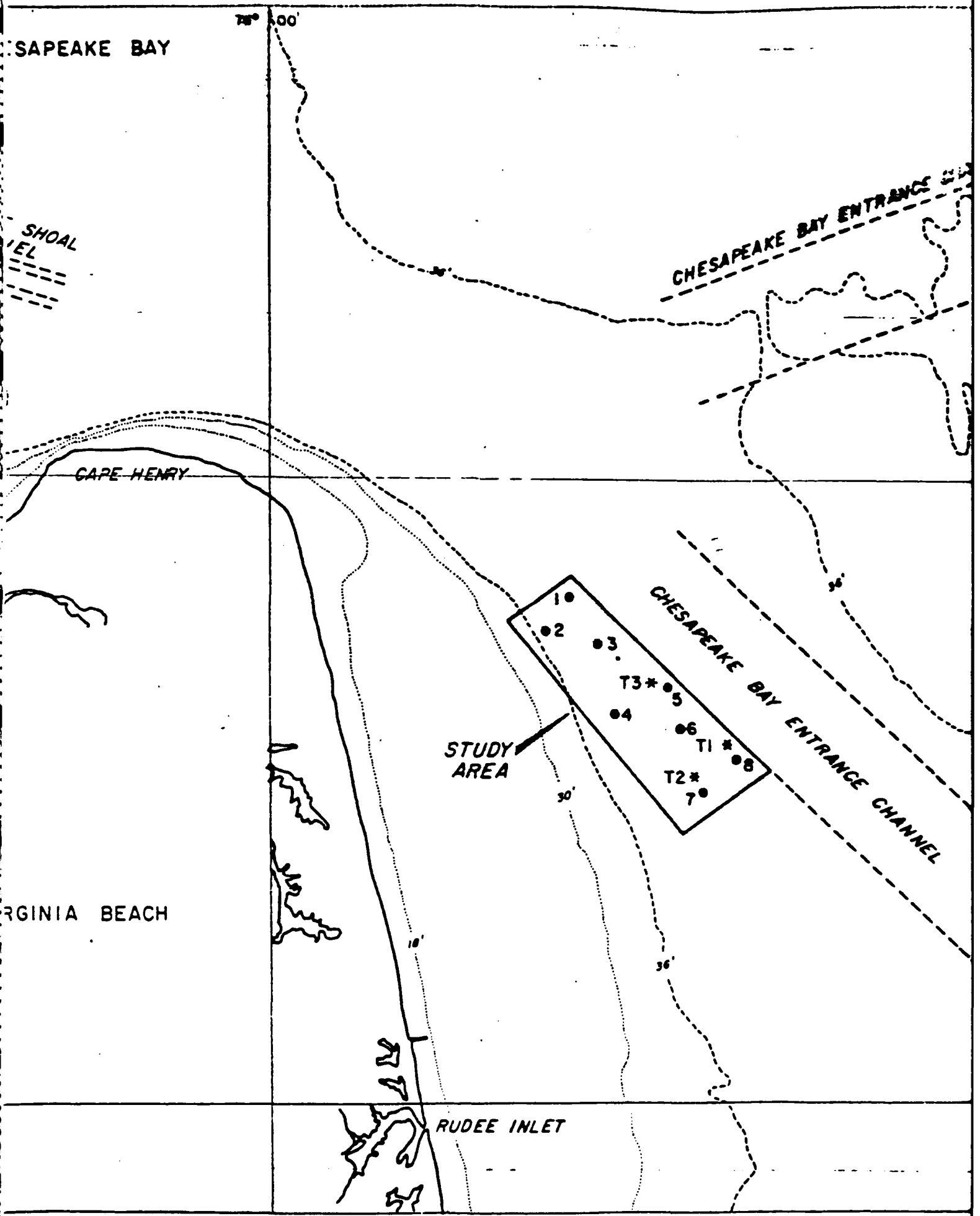


Fig. 6. Locations of benthic stations sampled by Hydroscience, Inc. (1974).

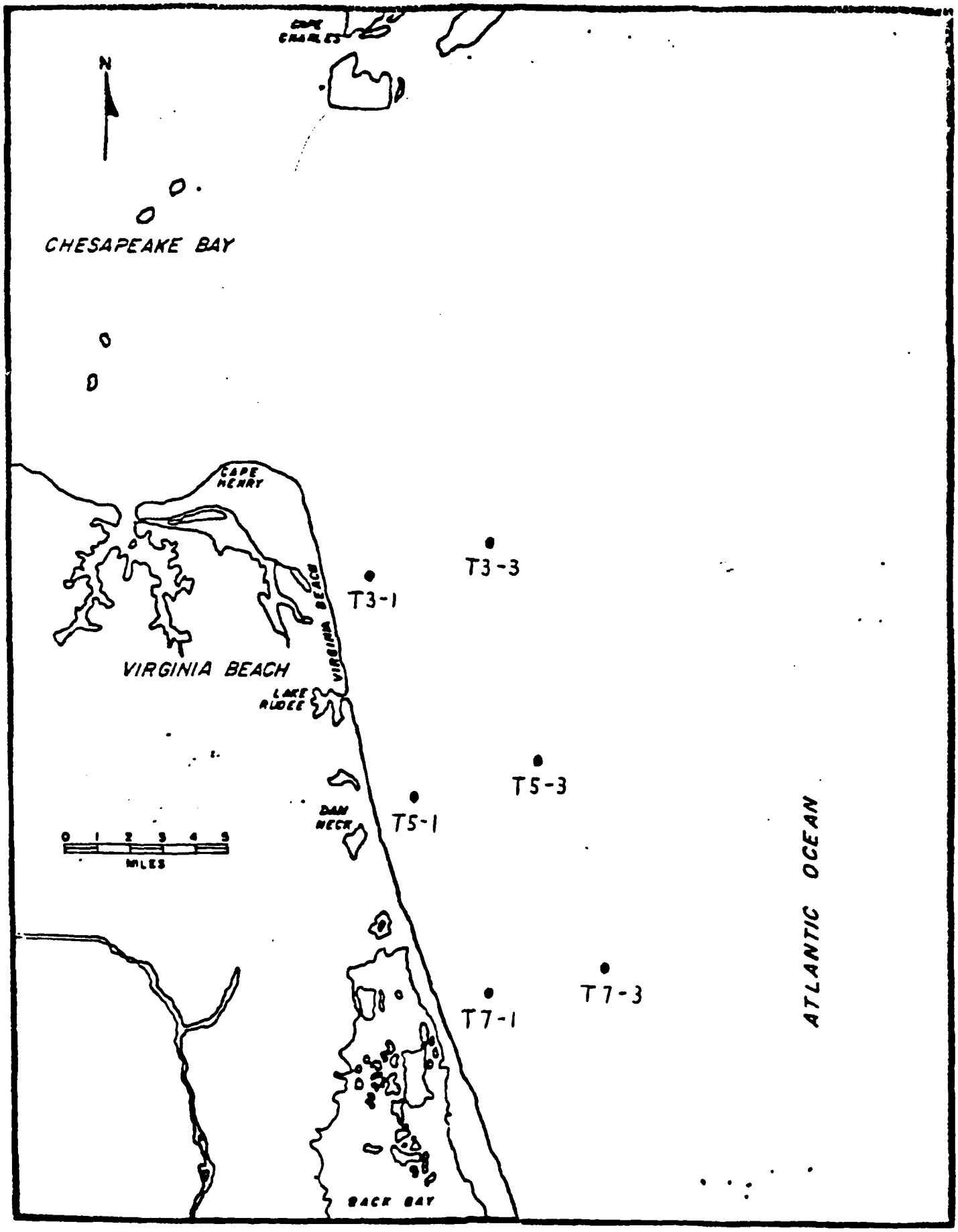


Table 1. Phytoplankton assemblages found by Marshall (1981) within the Chesapeake Bay plume and adjacent shelf waters for March, June, and October 1980. Numerical dominance is indicated for each collection period.

	Bay Entrance - Plume	Shelf
March	Asterionella glacialis	Bacteriastrum hyalinum
	Cyclotella sp.	Chaetoceros costatum
	Guinardia flaccida	Nitzschia longissima
	Leptocylindurs danicus	Rhizosolenia delicatula
	Leptocylindrus minimus	Thalassiosira nordenskioldii
	Nitzschia pungens	Thalassiorsira rotula
	Paralia sulcata	*Emiliania huxleyi
	Rhizosolenia delicatula	Green cells 5-10 microns
	Rhizosolenia fragilissima	
	*Skeletonema costatum	
	Thalassiosira nordenskioldi	
	Gomphosphaeria aponina	
	Nostoc commune	
	*Prorocentrum minimum	
	*Green cells <3 microns	
	*Green cells 3-5 microns	
June	Chaetoceros spp.	Rhizosolenia alata
	Cylindrotheca closterium	*Emiliania huxleyi
	Leptocylindrus danicus	Pontosphaera sp.
	Nitzschia pungens	Rhabdosphaera sp.
	Rhizosolenia delicatula	Syracosphaera pulchra
	*Skeletonema costatum	
	Green cells 3-5 microns	
October	*Asterionella glacialis	Nitzschia pungens
	Cerataulina pelagica	Rhizosolenia delicatula
	Cylindrotheca closterium	Rhizosolenia fragilissima
	Lauderia borealis	Skeletonema costatum
	Leptocylindrus danicus	*Emiliania huxleyi
	Nitzschia pungens	*Green cells <3 microns
	Rhizosolenia delicatula	*Green cells 3-5 microns
	*Skeletonema costatum	Mixed phytoflagellates
	*Emiliania hyxleyi	
	*Green cells <3 microns	
	*Green cells 3-5 microns	
	Anacystis sp.	
	Cryptomonas sp.	

*Dominant phytoplankters

Table 2. Species and abundance of fish, decapods, and molluscs collected by U.S. Fish and Wildlife Service (1981) using oblique daylight plankton tows at two stations near the mouth of Rudee Inlet (Fig. 4).

	Number/100m^2					
	May	June	July	Aug	Oct	Jan
FISH						
Ammodytes sp.						2
Anchoa hepsetus eggs				42		
Anchoa mitchilli eggs	11	1549	199	23		
Anchoa mitchilli		12	593			
Anchoa sp.				3261		
Cynoscion regalis				204		
Etropus microstomus			3			
Gobiesox strumosus				2		
Gobiosoma sp.				4		
Leiostomus xanthurus	2					
Membras martinica		3				
Morone americanus		2		31		
Peprilus sp. eggs			77	106		
Pogonias cromis (?)	30					
Tautoga omitis eggs	11					
Trinectes maculatus eggs		16		68		
Trinectes maculatus			8			
unid. Sciaenidae			10			
unid. Sciaenidae eggs	6	199	63	142		
DECAPODS						
Callianassa atlantica			55	837	2	
Callinectes sapidus		289	15	1973		
Cancer irrorata	4	4				
Crangon septemspinosa	15					10
Emerita talpoida		5	6	5	1	
Lucifer faxoni				20	52	
Naushonia crangonoides			5			
Neopanope sayi		20	35	46		
Ogyrides limicola					20	
Ovalipes ocellatus					2	
Pagurus longicarpus			3	33		
Palaemonetes sp.	1	3				
Pinnixa sp.		3	185	134	2	
Pinnotheres maculatus			6			
P. ostreum				5	38	
Rhithropanopeus harrissi				284		
Sesarma sp.			18	155		
Uca sp.		15	27	10		
Upogebia affinis		4	130	3476	5	

Table 2. (Cont.)

	Number/100m^2					
	May	June	July	Aug	Oct	Jan
MOLLUSCS						
Acteon punctostriatus		28	1602	2		
Cerithiopsis (?)					6	
Littorina sp.	6					
Mulinia lateralis				7		
Mytilus edulis	1					
Nassarius vibex			3	2		
Petricola pholadiformis				5		
Solen viridis				7		
Spiratella trochiformis				2		
unid. Turridae			2			

Table 3. List of zooplankton identified by Grant and Olney (1979, 1983) from bongo (oblique) and neuston (surface) tows conducted during day and night periods at stations in the vicinity of the Bay Bridge Tunnel (Fig. 4).

	March '79	August '79
COELENTERATA		
Bougainvillea sp.		x
Chrysaoura quinquecirrha		x
Cunina octonoria		x
Cyanea capillata	x	
Hydrocodon prolifer	x	
Liriope tetraphylla		x
Muggiaea kochei		x
Nemopsis bachei		x
Obelia sp.	x	x
Ruthkea octopunctata	x	
CTENOPHORA		
Pleurobrachia pileus	x	
NEMATODA		
unid. nemotodes	x	
POLYCHAETA		
Autolytus sp.	x	
Glycera dibranchiata	x	
Gyptis vittata		x
Harmathoe sp.	x	x
Hesionidae		x
Nereis succinea		x
Paranaitis speciosa	x	
Paraprionospio pinnata		x
Phyllodocidae		x
Polydora sp.	x	x
Polynoidae		x
Pseudeurythoe ambigua		x
Spionidae larvae	x	x
Syllidae		x
Terebellidae		x
Tomopteris helgolandica	x	x
MOLLUSCA		
Cerithiopsis sp.		x
Crassostrea virginica		x
Crepidula sp.		x
Ensis directus	x	
Epitonium sp.		x
Laevicardium mortoni	x	
Lilliguncula brevis		x

Table 3. (Cont.)

	March '79	August '79
MOLLUSCA (cont.)		
Limacina retroversa	x	
Littorina irrorata	x	x
Loligo pealeii		x
Lyonsia hyalina	x	
Macoma balthica	x	
Mulina lateralis	x	x
Mytilus edulis	x	
Nassarius obsoletus		x
N. vibex		x
Naticidae		x
Pholadidae		x
Tellina agilis	x	x
MEROSTOMATA		
Limulus polyphemus		x
MYSIPACEA		
Metamysidopsis mexicana		x
Mysidopsis bigelowi	x	x
Neomysis americana	x	x
CUMACEA		
Leptocuma minor	x	
Mancocuma sp.	x	x
Oxyurostylis smithi	x	x
ISAPODA		
Aegathea medialis		x
A. oculata		x
Edotea triloba	x	
AMPHIPODA		
Ampelisca abdita	x	x
A. agassizi		x
A. vadorum		x
Ampithoe longimana		x
Atylus minidoi		x
Batea catharinensis		x
Caprella equilibra	x	
Corophium insidiosum	x	
C. lacustre		x
Gammarus mucronatus	x	x
Idunella sp.		x
Jassa falacata	x	x
Lestrigonus bengalensis		x
Melita sp.		x
Microprotopus raneyi	x	x
Monoculodes edwardsi	x	

Table 3. (Cont.)

	March '79	August '79
AMPHIPODA (cont.)		
Paraplentes aestuarius		x
Phoxocephalus spinosus		x
Unciola irrorata	x	
CLADOCERA		
Evadne nordmani	x	x
Penilia avirostris		x
Podon polyphemoides	x	
COPEPODA		
Acartia clausi	x	
A. tonsa	x	x
Caligus chelifer		x
Centropages hamatus	x	x
C. typicus	x	x
C. velificatus		x
Corycaeus speciosus		x
Eucalanus crassus		x
E. pileatus	x	x
Eurytemora affinis	x	
Hemicyclops sp.	x	
Labidocera aestiva		x
Oithona sp.	x	x
Paracalanus crassirostris	x	x
P. indicus		x
P. quosimoda		x
Pseudocalanus sp.	x	
Pseudodiaptomus coronatus		x
Temora longicornis	x	
CIRRIPEDIA		
Balanus balanoides (?)	x	
Lepus sp.	x	
unid. barnacle larvae		x
STOMATOPODA		
Squilla empusa		x
DECAPODA		
Alpheus normanni		x
Callianassa atlantica		x
C. biformis		x
Callinectes sp.		x
Crangon septemspinosa	x	x
Euceramus praelongus		x
Hexapanopeus angustifons		x
Libinia emarginata		x
L. dubia		x

Table 3. (Cont.)

	March '79	August '79
DECAPODA (cont.)		
Lucifer faxoni		x
Naushonia crangonoides		x
Neopanope sayi		x
Ogyrides limicola		x
Ovalipes occellatus		x
O. stephensoni		x
Pagurus longicarpus		x
Palaemonetes sp.		x
Panopeus herbstii		x
Pinnixa chaetopterana		x
P. cylindrica		x
P. sayana		x
Pinnotheres maculatus		x
P. ostreum		x
Portunus sp.		
Uca sp.		x
Upogebia affinis		x
PHORONIDA		
unid. phoronid larvae	x	
CHAETOGNATHA		
Sagitta elegans	x	
S. enflata		x
S. hispida		x
S. tenuis		x
TUNICATA		
Oikopleura sp.		x
PISCES		
Ammodytes hexapterus	x	
Anchoa hepsetus		x
A. mitchilli	x	
Anguilla rostrata	x	
Atherinidae	x	x
Centropristis striata		x
Cynoscion nebulosus		x
C. regalis		x
Etropis microstomus		x
Gadus morhua	x	
Gobiosoma sp.		x
Hypsoblennius hentzi		x
Menticirrhus sp.		x
Peprilus paru		x
P. trincanthus		x
Prionotus sp.		x

Table 3. (Cont.)

	March '79	August '79
PISCES (cont.)		
Pseudopleuronectes americanus	x	
Rissola marginata		x
Symphurus plagiusa		x
Syngnathus fuscus	x	
Trinectes maculatus		x
unid. ophidiid		x
unid. pleuronectiform		x

Table 4. List of zooplankton identified by Grant et al (1979) from oblique and surface tows conducted during day and night periods at a coastal station off the eastern shore of Virginia (Fig. 4).

	Fall '76	Winter '77	Spring '77	Summer '77
CNIDARIA				
Abylopsis eschscholtzii	x			
Abylopsis tetragona	x			
Aequorea sp.				x
Agalma elegans	x			
Bassia bassensis	x			
Catablema vesicarium				x
Diphyes chamissoni	x			
Diphyes dispar	x			
Diphyopsis campanulifer	x			
Liriope sp.	x			x
Liriope tetraphylla	x			
Muggiaea kochei	x			
Obelia sp.				x
Pelagia noctiluca	x			
Rhacostoma atlanticum				x
unid. anthozoans	x			
unid. hydrozoans				x
TURBELLARIA				
unid. flatworms	x			x
ANNELIDA				
Tomopteris helgolandica				x
unid. polychaetes	x	x	x	x
MOLLUSCA				
Atlanta peroni	x			x
Cavolina longirostris	x			
Cerastoderma pinnulatum		x		x
Creseis virgula	x			x
Ensis directus		x	x	
Hyalocyclis striata				x
Lima tenera	x			
Limacina retroversa			x	
Limacina trochiformis	x			x
Loligo pealii	x		x	x
Lunatia triseriata			x	
Macoma balthica		x	x	
Paedoclione doliiformis			x	x
Rossia tenera				x
Spisula solidissima	x	x	x	
unid. gastropods				x

Table 4. (Cont.)

	Fall '76	Winter '77	Spring '77	Summer '77
CLADOCERA				
Evadne nordmanni			x	x
E. spinifera				x
E. tergestina	x			x
Penilia avirostris	x			x
Podon sp.				x
Podon leuckartii			x	
OSTRACODA				
Conchoecia bispinosa		x		
Euconchoecia chierchine	x			
COPEPODA				
Acartia sp.				x
A. clausi				x
A. danae	x			
A. tonsa				x
Anomalocera sp.			x	
A. ornata	x		x	
A. patersonii			x	
Calanus finmarchicus		x	x	x
Candacia armata	x			x
Caligus chelifer				x
Centropages furcatus	x			x
C. hamatus		x	x	x
C. typicus	x	x	x	x
C. violacens	x			
Clausocalanus arevicornis		x		
Copilia mirabilis				x
Corycaens sp.	x	x	x	x
C. lautus				x
C. speciosus	x			x
Eucalanus sp.	x	x		
E. crassus	x			x
E. pileatus	x			x
Euchaeta marina		x		
Eurytemora sp.				x
E. americana	x			
Labidocera sp.	x			x
L. aestiva	x			x
Mecynocera clausi	x			
Metridia lecens	x	x		
Nannocalanus minor	x			x
Oithona sp.	x		x	x
Oncaea conifera	x			
O. mediterranea	x			
O. venusta	x			
Paracalanus sp.	x	x	x	

Table 4. (Cont.)

	Fall '76	Winter '77	Spring '77	Summer '77
COPEPODA (cont.)				
P. parvus	x			
Pleuromamma gracilis	x	x		
Pontella sp.	x			x
P. meadii	x			x
Pontellopsis villosa	x			
Pseudocalanus sp.			x	x
Rhincalanus nasutus	x	x		
Sapphirina sp.	x		x	
S. nigromaculata	x			x
Scolecithrix danae	x			
Temora sp.			x	
T. longicornis			x	x
T. stylifera	x			x
T. turbinata	x		x	
Tortanus discaudatus			x	x
Undinula vulgaris	x			
CIRRIPEDIA				
Chthamalus fragilis		x		x
unid. barnacle larvae			x	x
STOMATOPODA				
unid. stomatopod larvae	x		x	x
MYSIDACEA				
Bowmaniella sp.	x			x
Heteromysis formosa		x	x	
Mysidopsis bigelowi	x	x	x	
Neomysis americana		x		
Promysis atlantica	x			
CUMACEA				
Cyclaspis sp.			x	x
Leptocuma minor		x	x	x
Leucon americanus	x		x	x
Oxyurostylis smithi	x		x	x
ISOPODA				
Chiridotea tuftsi			x	x
Edotea triloba				x
Idotea balthica				x
I. metallica	x		x	

Table 4. (Cont.)

	Fall '76	Winter '77	Spring '77	Summer '77
AMPHIPODA				
Acanthostepheia sp.			x	
Ampelisca agassizi			x	
A. verrilli				x
Ampithoe longimana				x
Argissa hamatipes			x	x
Byblis serrata			x	
Corophium acheruscium			x	
Gammarus sp.			x	
Lestrigonus sp.				x
L. bengalensis	x			x
Lycaea sp.				x
Lycaeopsis neglecta	x			
Microprotopus raneyi				x
Monoculodes sp.		x	x	
Parametopella cypris			x	
Parathemisto gandichandii	x	x		
Protohaustorius wigleyi			x	
Syncholidium americanum				x
Themistella fusca	x			x
Trichophoxus epistomus				x
Unciola irrorata				x
unid. gammarids		x		
unid. caprellids	x			
unid. hyperiids				x
EUPHAUSIACEA				
Euphausia sp.	x			
Thysanoessa sp.	x	x		
unid. euphausiids	x	x		
DECAPODA				
Arenaens sp.				x
Callianassa sp.	x			
Callinectes sp.	x			x
Cancer sp.	x		x	
Crangon septemspinosa	x	x	x	x
Dichelopandalus leptocerus			x	
Dromida antillensis	x			
Emerita sp.				x
Hexapanopeus augustifrons				x
Homarus americanus			x	
Leptochela sp.	x			
Libinia sp.	x			
Lucifer faxoni	x			x
Naushonia crangonoides				x
Ocypode quadrata				x
Ovalipes sp.	x			

Table 4. (Cont.)

	Fall '76	Winter '77	Spring '77	Summer '77
DECAPODA (cont.)				
Portunus sp.	x			x
Processa sp.	x			
Sergestes sp.	x			
Uca sp.				x
Upogebia affinis				x
unid. calappids			x	
unid. hippolytids				x
unid. leucosiids	x			
unid. pagurids	x			x
unid. palaemonids				x
unid. penaeids				x
unid. xanthids	x			
ECHINODERMATA				
unid. asteroids	x			
unid. ophinroids	x			
CHAETOGNATHA				
Sagitta elegans		x	x	x
S. enflata	x			x
S. helenae	x			
S. hispida	x			x
S. minima	x			
S. serratodentata	x			
S. tasnanica	x	x		
S. tenuis	x			x
TUNICATA				
Doliolum sp.				x
D. nationalis	x			x
Oikopleura sp.	x			x
PISCES				
Ammodytes sp.		x	x	
Anchoa sp.	x			x
Astroscopus guttatus	x			x
Bothus sp.	x			
Citharichthys arctifrons				x
Conger oceanicus			x	
Cynoscion regalis	x			
Enchelyopus cimbrius			x	
Etropus microstomus				x
Gasterosteus aculeatus			x	
Gobiosoma ginsburgi	x		x	x
Hypsoblennius hentzi				x
Limanda ferruginea			x	
Lophius americanus			x	

Table 4. (Cont.)

	Fall '76	Winter '77	Spring '77	Summer '77
PISCES (cont.)				
Menidia minidia		x		
Merluccius sp.	x			
Paralichthys dentatus	x			x
Peprilus triacanthus				x
Pomatomus saltatrix			x	x
Scophthalmus aquosus	x		x	x
Symphurus sp.				x
Tylosurus acus				x
Urophycis sp.	x		x	
unid. engraulids	x			
unid. ophidiids				x
unid. scorpaenids				x

Table 5. Macrobenthic species sampled with Shipek grab by FWS (1982) and the stations (see Fig. 4) at which they occurred.

Taxa	Common Name	Stations Where Collected
CNIDARIA		
Anthozoa (unidentified)	anemone	1 2 6
PLATYHELMINTHES		
Turbellaria (unidentified)	flatworm	8
NEMERTEA		
unidentified Nemertean	nemertean worm	1 2 3 4 5 6 7 8
PHORONIDA		
Phoronis sp.	phoronid worm	2 3 4 7 8
MOLLUSCA		
Gastropoda		
Crepidula fornicata	slipper shell	5 8
Mitrella lunata	lunar mitrella	1 2 4
Nassarius trivittatus	mud snail	1 3 8
Natica pusilla	moon shell	3
Retusa candea	lathe shell	2
Turbonilla interrupta	pyramid shell	2 4 5 7
Pelecypoda		
Anadara transversa	transverse ark shell	1
Ensis directus	razor clam	1 2 3 4 5 6 7 8
Gemma gemma	gem shell	8
Lyonsia hyalina	transparent lyonsia	7 8
Mulinia lateralis	little surf clam	2
Mytilus edulis	blue mussel	1 2 3 4 5 6
Nucula proxima	nut shell	2 5 6 8
Siliqua costata	ribbed pod shell	7
Spisula solidissima	surf clam	1 4 5 6 7 8
Tellina agilis	tellin shell	1 2 3 4 5 6 7 8
Yoldia limatula		2 3 4
ANNELIDA		
Polychaeta		
Ampharete acutifrons		1 2 3 4 5 6 7 8
Amparete americana		2 3 5 6 8
Ampharetidae sp. (juvenile)		1 2 3 4 5
Amastigos caperatus		1 2 3 4 5 6 7 8
Ancistrosyllis hartmanae		1 5 6 8
Aproprionospio pygmaea		7 8
Aricidia catherinae		1 5 6 7 8
Aricidia wassi		5 7
Asabellides oculata		6
Capitella capitata		1 2 3 4
Capitella sp. (juvenile)		
Cirratulidae spp.		1 2 3 4 5 6 7 8

Table 5. (Cont.)

Taxa	Common Name	Stations Where Collected
ANNELIDA, cont'd.		
Polychaeta		
Cirrophorus furcatus		1 2 4 5 6 8
Clymenella torquata	bamboo worm	3 4 7 8
Diopatra cuprea		1 2
Dorvilleidae sp. (juvenile)		6 7
Eteone heteropoda		1 2 6
Eteone lactea		1 5 6 7 8
Eumida sanguinea		4
Glycera americana	bloodworm	1 2 3 4 5 6 7 8
Glycera dibranchiata	bloodworm	1 3 4 5 6 7 8
Glycera sp. (juvenile)	bloodworm	1 2 3 4 6 7
Goniadella gracilis		2 3
Harmothoe extenuata		1 2 3 4 8
Hemipodus roseus		8
Linopherus ambigua		6
Lumbrineris tenuis		5 6 8
Macroclymene zonalis		4 5 6 8
Magelona sp.		1 2 3 4 5 6 7 8
Maldanidae sp. (juvenile)		1 4 7 8
Mediomastus ambiseta		1 2 3 4 5 6 7 8
Microphthalmus sczelkowii		6
Nephtys picta		2 3 4 5 6 7
Nereidae sp. (juvenile)	clam worm	1
Nereis succinea	clam worm	1
Notomastus hemipodus		4 7 8
Ophelia sp.		6
Owenia fusiformis		8
Paleonotus heteroseta		3
Paranaitis speciosa		3 4 8
Phyllodoce arenae	paddle worm	2 3 4 5 6 7 8
Phyllodoce sp. (juvenile)	paddle worm	7
Phyllodocidiae sp. (juvenile)	paddle worm	3
Pista cristata		2
Polydora websteri		2 4 8
Polydora sp. (juvenile)		1 2 3 4 5 7
Polygordius sp.		1 2 3 4 5 6 7 8
Protodorvillae kefersteini		1 4 5 6
Sabellaria vulgaris	sand builder worm	1
Scalibregma inflatum		6 8
Schistomeringos caeca		1 4 5 6 7 8
Schistomeringos rudolfi		1 5 6
Scolelepis sp.		4 7
Scoloplos robustus		1 4 7 8
Scoloplos sp. (juvenile)		1 6
Sigambra tentaculata		2 3 6
Spio setosa		1 2 3 4 5 6 7 8

Table 5. (Cont.)

Taxa	Common Name	Stations Where Collected
ANNELIDA, Cont'd.		
Polychaeta		
Spiochaetopterus oculatus		2
Spiophanes bombyx		1 2 3 4 5 6 7 8
Streblospio benedicti		2 3 4 5 7 8
Syllidae spp.		1 2 4 5 6 8
Oligochaeta		
Oligochaeta spp.	oligochaete worms	1 2 3 4 5 6 7 8
ARTHROPODA		
Crustacea		
Cumacea		
Oxyurostylis smithi		5 6 7 8
Isopoda		
Edotea sp.		1 4 6 7 8
Amphipoda		
Ampelisca verrilli		7
Corophium spp.		1 2 3
Synchelidium americanum		1
Unciola irrorata		2 3 4 5 6 7 8
Unciola serrata		6
Unciola sp.		3 5
Decapoda		
Pagurus sp.	hermit crab	5
Pinnixa sp.	commensal crab	2 5 7
ECHINODERMATA		
Echinoidea sp.	sand dollar	1 2 5 6 7 8
CEPHALOCHORDATA		
Branchiostoma virginiae	lancelet	1 4 5 6 7 8

Table 6. Epibenthic species sampled with otter trawl by FWS (1982) and the stations (see Fig. 4) at which they occurred.

Taxa	Common Name	Stations Where Collected		
MOLLUSCA				
Gastropoda				
Busycon canaliculatum	channeled whelk		T2	
Crepidula fornicata	slipper shell	T1		
Nassarius trivittatus	mud snail		T2	
Pelecypoda				
Mytilus edulis	blue mussel		T2	T3
Cephalopoda				
Loligo pealei	common squid	T1		T3
Lolliguncula brevis	brief squid		T2	
ARTHROPODA				
Merostomata				
Limulus polyphemus	horseshoe crab		T2	
Crustacea				
Callinectes sapidus	blue crab			T3
Cancer irroratus	rock crab	T1	T2	T3
Libinia emarginata	spider crab		T2	
Pagurus longicarpus	hermit crab	T1	T2	T3
Pagurus pollicaris	hermit crab	T1		
Panopeus herbstii	mud crab			T3
ECHINODERMATA				
Echinoidea				
Asterias forbesi	common starfish		T2	
CHORDATA				
Pisces				
Carangidae sp.	scad			T3
Centropristes striata	black sea bass		T2	T3
Cottus sp.	sculpin	T1	T2	T3
Etropus microstomus	smallmouth flounder	T1		T3
Prionotus carolinus	searobin	T1		T3
Raja eglanteria	clearnose skate	T1	T2	T3
Scophthalmus aquosus	windowpane		T2	
Stenotomus chrysops	southern scup	T1	T2	
Urophycis regia	spotted hake	T1	T2	T3

Table 7. List of benthic species reported by Hydroscience, Inc. (1974) and the stations at which they occurred (see Fig. 5).

TAXA	Stations T3-1	T3-3	T5-1	T5-3	T7-1	T7-3
CNIDARIA						
Halcampoides sp.	x					
Hydractinia sp.				x		
Lovenella gracilis		x				
NEMERTEA						
unid. nemertean			x	x		x
NEMATODA						
unid. nematode		x	x	x		
BRYZOA						
Electra sp.				x		
POLYCHAETA						
Ampharete acutifrons				x	x	
Amphicteis gunneri						x
Aricidea cerruti	x	x			x	x
Branchiostoma caribeaum					x	x
Brania dispar						x
Ceratonereis irritabilis				x		
Diopatra cuprea				x		
Drilonereis filum	x	x	x	x		
D. magna					x	
Exogone setosa						x
Glycera dibranchiata	x	x	x	x	x	
Heteromastus filiformis				x		
Lepidonotus sublevis				x		
Loimia medusa				x		
Magelona rosea	x		x			
Nephtys magellanica	x					
N. picta		x			x	
Nereis succinea				x		
Notomostus sp.	x	x	x		x	x
Odontosyllis fulgurans					x	x
Owenia fusiformis	x		x			x
Paraonis fulgons		x				
Phyllodoce mucosa				x		
Phylo felix					x	
Polycirrus eximins				x	x	
Polydora sp.					x	
P. socialis				x		
Polygordius sp.		x		x	x	x
Prionospio cirrifera				x		
P. dayi			x			

Table 7. (Cont.)

TAXA	Stations T3-1	T3-3	T5-1	T5-3	T7-1	T7-3
POLYCHAETA (cont.)						
Sabellaria vulgaris		x		x	x	
Scolecolepides viridis						x
Scoloplos fragilis	x					
Sigalion arenicola					x	x
Spio setosa					x	x
Spiochaetopterus oculatus				x		
Spiophanes bombyx	x	x	x			
Tharyx marioni			x	x	x	x
Tharyx setigera	x					
Travisia parva					x	x
OLIGOCHAETA						
unid. oligochaetes	x	x		x	x	
GASTROPODA						
Acteocina canaliculata			x			
Clione sp.		x			x	
Crepidula convexa		x		x	x	
Cylichna alba			x			
Doridella obscura				x		
Mitrella lunata				x		
Polinices duplicatus					x	
Turbonilla interrupta			x			
BIVALVIA						
Abra aequalis	x	x	x	x	x	x
Amygdalum papyria			x			
Mercenaria sp.	x					
Mercenaria mercenaria			x			
Modiolus sp.				x		
Nucula proxima		x		x	x	
Pandora trilineata		x			x	
Spisula solidissima		x			x	
Tellina virsicolor	x		x	x	x	x
CIRRIPEDIA						
unid. barnacles	x					
STOMATOPODA						
Squilla empusa					x	
CUMACEA						
Oxyurostylis smithi	x		x		x	
ISOPODA						
Edotea triloba			x			

Table 7. (Cont.)

TAXA	Stations T3-1	T3-3	T5-1	T5-3	T7-1	T7-3
AMPHIPODA						
Ampelisca verrilli				x		
Corophium acherusicum				x		
Erichthonius brasiliensis				x		
Photis sp.				x		
Protohaustorius wigleyi						x
Stenothoe minuta				x		
Trichophoxus epistomus	x	x		x		
Unciola irrorata				x	x	
MYSIDACEA						
Neomysis americanus	x	x	x	x	x	
DECAPODA						
Callanassa atlantica					x	
Crangon septemspinosa	x			x		
Euceramus praelongus				x	x	
Pagurus annulipes	x		x	x		
P. pollicaris				x		
Pinnixa chaetopterana	x	x		x	x	
Portunus sayi				x		
Pelia mutica				x		
unid. xanthid		x		x		
ECHINODERMATA						
Mellita quinquiesperforata						x

Table 8. List of species collected during NMFS groundfish surveys conducted along three depth transects between the mouth of Chesapeake Bay and the Virginia/North Carolina border. The list is based on four annual surveys from 1977 through 1980 with 3 cruises conducted each year, usually in late March, early August and late September.

	Fathoms		
Species	0-5	5-10	10-15
Odontaspis taurus			x
Mustelus canis	x	x	x
Carcharhinus obscurus		x	
Rhizoprionodon terraenovae	x	x	x
Sphyrna lewini	x		
Squalus acanthias	x	x	x
Squatina dumerili	x	x	x
Raja eglanteria	x		x
R. erinacea		x	
Aetobatus narinari	x		
Dasyatis centroura		x	
D. sabina	x		
Gymnura altavela	x	x	x
G. micrura	x		
Myliobatis freminvilli	x	x	x
M. goodei	x		
Rhinoptera bonasus	x		
Accipenser oxyrhynchus		x	
Clupea harengus	x	x	x
Alosa aestivalis	x	x	x
A. pseudoharengus	x	x	x
A. sapidissima	x	x	
Opisthonema oglinum	x	x	
Brevoortia tyrannus	x	x	
Etrumens salina		x	x
Anchoa mitchilli	x	x	x
A. hepsetus	x	x	
A. lyolepis		x	x
Conger oceanicus		x	
Synodus foetens	x	x	x
Urophycis chuss	x	x	x
U. regia	x	x	x
Merluccius bilinearis	x	x	x
Paralichthys dentatus	x	x	x
Pseudopleuronectes americanus	x		x
Etropus microstomus	x	x	x
Citharichthys arctifrons		x	x
Scophthalmus aquosus	x	x	x
Trinectes maculatus	x		
Symphurus plagiusa		x	x
Syngnathus fuscus		x	
Menidia menidia	x	x	x

Table 8. (Cont.)

Species	Fathoms 0-5	5-10	10-15
Ammodytes americanus	x	x	x
Scomber scombrus		x	x
Trichiurus lepturus		x	
Peprilus alepidotus	x	x	
P. triacanthos	x	x	x
Selar crumenophthalmus	x	x	
Seriola zonata	x		
Caranx fusus	x	x	
C. bartholomaei	x		
Selene setapinnis		x	
Trachurus lathami		x	x
Pomatomus saltatrix	x	x	x
Centropristis striata		x	x
Stenotomus chrysops	x	x	x
S. caprinus	x	x	x
Leiostomus xanthurus	x	x	x
Micropogonias undulatus	x	x	x
Menticirrhus saxatilis	x	x	
M. americanus	x	x	
Cynoscion regalis	x	x	x
Prionotus evolans	x	x	x
P. tribulus			x
Tautoga onitis			x
Astroscopus guttatus		x	
Ophidium marginatum	x	x	x
Monacanthus hispidus	x	x	
Sphoeroides maculatus	x	x	x
S. trichocephalus	x		
Lophius americanus	x		
Decapterus punctatus		x	x
Macrozoarces americanus			x
Total	53	58	45
All total	76 species		

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END